The Application of Articial Intelligence and Machine Learning in Academic Libraries

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INTRODUCTION

The study of Artificial Intelligence (AI) and Machine Learning (ML) is both inter and multidisciplinary. This is because the concepts of AI and ML are an integration of computer science, behavioural and social sciences. This has seen these technologies being adopted across various disciplines to facilitate solving problems related to data collection, storage, organization, processing, dissemination, communication and the broader areas of information processing. Research on these cross-cutting technologies has not been limited to one discipline although to laypeople the concept of AI and ML could easily be associated with computer science.

Among some fields that have increasingly adopted artificial intelligence is the field of library and information science. The 21st-century librarianship and the broader information science discipline across the globe have handled diverse ever-increasing volumes of information. In addition to this, the information and knowledge world of the century has produced patrons of various backgrounds all looking up to the libraries and the broader information environment to meet their information needs. This has called for stronger adaptation and adoption approaches in proving information services and complementing human effort and expertise with the distant potential to completely substitute human expertise and skills. Under the current knowledge and information environment, human expertise is limited in providing services to these diverse users.

The 21st-century library users have become digital users often demanding independent use of digital library resources. Besides this, the library has also diversified its services to provide a fountain of solutions to problems confronting humanity. Users in their various categories, have continuously realized and acknowledged the vitality of libraries in providing information that enables information users to address problems that confront them daily. Traditional libraries have often been ill-equipped to address these needs. It has been suggested that through the use of artificial intelligence, collections can be enhanced to become more useful to patrons (Cordell, 2020). Despite the seemingly low research and usage of AI in libraries, associations such as the International Federation of Library Associations (IFLA), the American Library Association (ALA) and the Canadian Federation of Library Associations (CFLA) among others have begun to acknowledge the importance of AI in libraries and have also recommended AI innovations among their membership (Wheatley & Hervieux, 2019). This chapter will examine key concepts of artificial intelligence and machine learning together with their applications in library and information science. Key challenges and opportunities offered to the broader discipline of librarianship will also be discussed.

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BACKGROUND

This section presents the basic concepts of artificial intelligence and machine learning. This covers key definitions of AI and the different branches of AI as well as the diverse generic application areas of AI. The section also defines machine learning and the types of machine learning together with the associated algorithms. Generic applications of machine learning are also presented.

Basic Concepts of Artificial Intelligence

Historically, humans have always dreamed of nonhuman creatures that could solve problems beyond human capabilities (Griffey, 2019). Actualizing such dreams would make humans accomplish tasks that they perceive to be beyond their capabilities. Such dreams then resulted in a sequence of inventions and automation activities that were witnessed by individuals like Ad Lovelace and Charles Babbage, who sought to utilise the growth of computing technology to manage complex problems confronting humanity. This led to the development of technologies that provide platforms for machines to learn like humans, to interpret and employ information to execute tasks with capabilities traditionally associated with human experts. These technologies, called Artificial Intelligence, however, lack reasoning associated with humans.

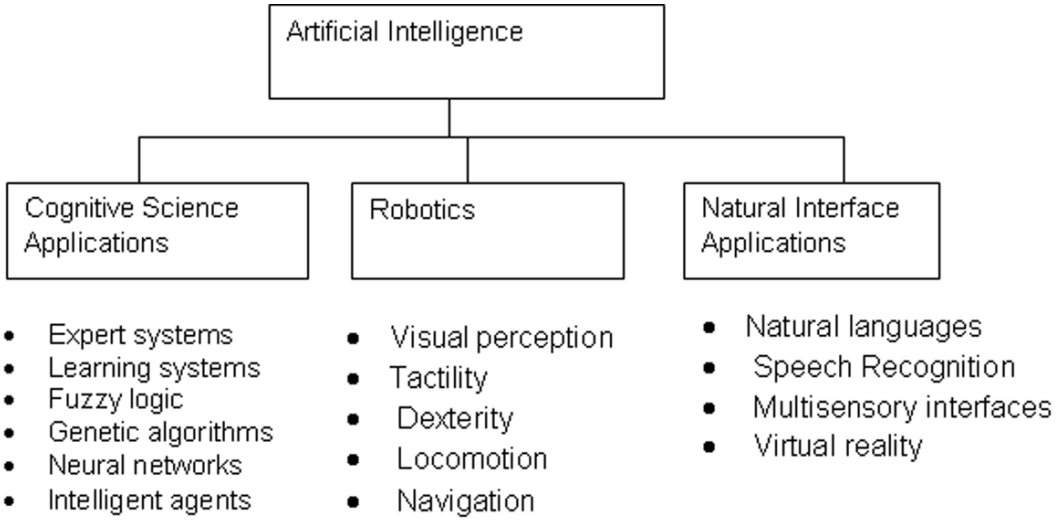
Definitions of AI seem to vary from one text to the other but generally, it is described as a computer system that can think and act on its own with no supervision. Often writers have described AI as a study of how to make computers do things which at the moment people can do better (Ertel, 2017). This enables computers or computer-controlled robotics to solve problems that are normally associated with higher intellectual capabilities of humans. Key characteristics of AI are: thinking humanly, acting humanly, thinking rationally, and acting rationally (Russel & Norvig, 2010). The concept of thinking humanly involves computer systems with minds, capable of making decisions and solving problems with excellence that would normally be associated with humans. The development of such applications involves observations on how humans solve problems and argue that computer systems go about similarly solving problems. Acting humanly refers to machines that perform functions that require intelligence when performed by people. To be considered intelligent, a computer system must be able to act sufficiently like a human. Thinking rationally involves studying computers that make it possible to perceive, reason and act. Thinking rationally involves making correct inferences based on logic and then acting on one's conclusions. Acting rationally focuses on performing actions that would enable one to achieve one's goals. Intelligent agents display intelligent behaviours by performing actions that result in goal attainment. These capabilities seem to be relevant and have become widely available in library systems to support reference services and recommender systems through innovations in robotics and chatbots.

The major categories of AI according to Quintarelli et al., (2021) are:

i) Artificial General Intelligence (AGI): This involves machines with human capabilities to learn and understand tasks. This suggests that machines have cognitive reasoning and problem-solving abilities.
ii) Artificial Super Intelligence (ASI): This technology not only resembles human intelligence but can exceed and surpass it
iii) Narrow Artificial Intelligence (Weak AI): While this still resembles human intelligence, it does this in a narrow scope.

A simplified classification of AI by Borana (2016) describes AI, as either Strong AI or Weak AI. The principle of strong AI is that in the future machine will be invented that represent the human mind and human intelligence, completely substituting humans. However, current research on AI has not successes in developing such kinds of machines. The principles of weak AI are to have machines that act as if they are intelligent, for example in gaming. Based on the applications of AI in specific domains, Borana (2016) identifies three major application areas of AI and these are cognitive science applications, robotics and Natural Interface Applications. The figure below represents the categorisation:

Figure 1. Artificial Intelligence Applications (Source: Borana, 2016)

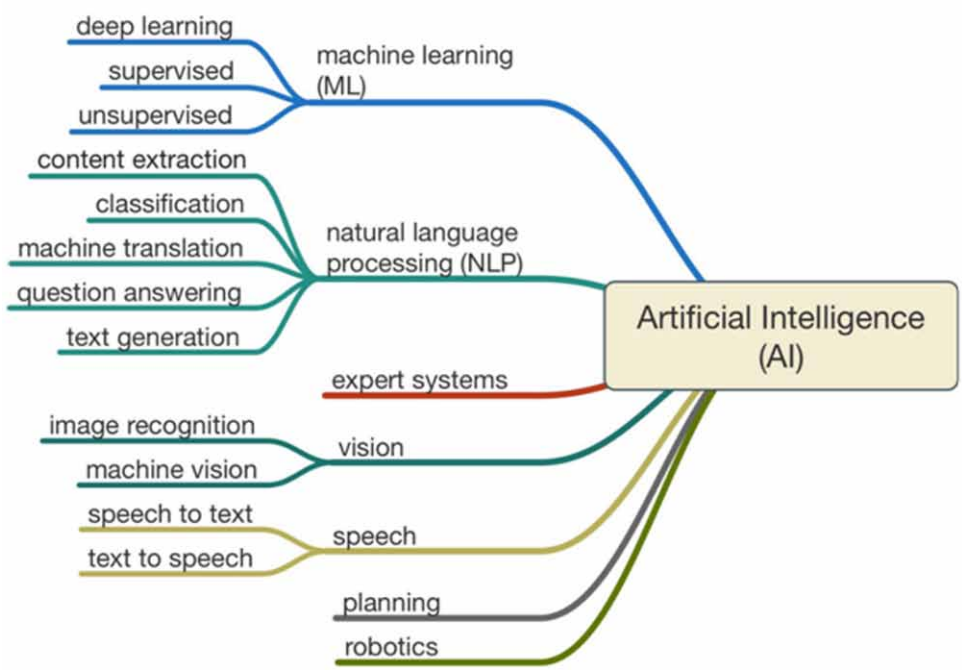


As shown in Figure 1 above, cognitive science applications comprise expert systems, learning systems, fuzzy logic, neural networks and intelligent agents. Robotics have been applied in applications that require visual perceptions and navigation. Natural language applications have been in speech recognition and natural language processing. Mohammed (2019) also categorised various application areas of AI according to these fields as shown in Figure 2 below:

Some applications of AI as shown in Figure 2 above have been in machine learning and natural language processing among others. This has seen these technologies being applied in a wide range of fields and among them are engineering and business (Adejo & Misau 2021). Applications of AI as shown in Figure 2 have also developed their subfields.

According to Jallow, Renukkappa & Suresh (2020), the sooner the organization can adopt AI, the more they can add to the longevity of the business because AI enables them to scale and provide answers. To that end, therefore, the field of Library and Information Science has increasingly acknowledged the potential role of AI information services. Traditional libraries have been large buildings housing large volumes of print content. These institutions have evolved and embraced modern technologies to address diverse information needs across different sectors of users. Modern libraries have now manage complex datasets that imposes computing limitations on human brains, and this has called for the integration of traditional library processes with modem technologies. Despite that, AI as a field has often received inadequate attention from knowledge workers.

Figure 2. Fields of Artificial Intelligence (Source: Mohammed, 2019)



The development of intelligent libraries is increasingly being driven by AI in developing nations due to the requirement to keep up with global trends in information and communication technologies (ICTs). These innovations have made it easier for libraries to evolve from resource-driven to service-driven, allowing libraries to manage enormous volumes of varied, fast-moving data, thatv characterises the driven Fourth Industrial Revolution (4IR). The data-driven 4IR requires information from all sectors to support its operations, which has made matters worse. This is because traditional libraries have kept a variety of records and were built to house expansive collections and reading areas. However, as users increasingly turn to the internet and e-resources, these collections have outgrown library facilities, and reading areas have become obsolete, forcing libraries to adopt cutting-edge technology to support the delivery of information services and to structurally evolve in terms of the collections they create and the services they provide. The goal of implementing these new technologies is to reduce human involvement, boost productivity, neutralize workload, and create smart and intelligent libraries (Das & Islam, 2021).

Machine Learning Concepts

At its most basic level, ML refers to the ability of the computer to learn by itself from past experiences and to address complex tasks without having to be explicitly programmed by a human (Wehle, 2017; Daimari et al., 2021). This process begins with observations and the identification of data patterns to make predictions. Machine learning models can be supervised learning, unsupervised learning, reinforcement learning, deep learning or deep reinforcement learning. In supervised machine learning the user trains the program to generate answers based on known and labelled data sets (Wehle, 2017). Classification and regression algorithms based on randomization, forecasts, decision trees and support vector machines are currently used in supervised learning. In unsupervised, algorithms generate answers on unknown and unbalanced data sets. This is used for discovering patterns in new data sets and clustering

algorithms such as K-means are mostly used. The objective of K-means is to group similar data points and discover underlying patterns. In reinforcement learning, agents operate in an environment characterised by feedback and a fixed dataset. The focus is to balance the need to explore new solutions and exploring learning solutions. Deep learning extracts required data from large unstructured datasets by passing the dataset through multiple layers where each layer extracts data that satisfy particular criteria. After passing through several layers, results from these layers are then integrated to provide a holistic view of the data. Reinforcement learning is applied in sequential control strategies, where the output of a system is a sequence of actions performed to achieve a goal. For example, in learning to rank, the aim is to construct a ranking model from training data (Lawrynowicz & Tresp, 2014). Deep reinforcement learning provides techniques for both deep and reinforcement learning.

Among some tasks that ML algorithms are intended to solve are classification and regression, learning associations, clustering, reinforcement learning, and learning to rank and structure predictions (Lawrynowicz & Tresp, 2014). This is common seen in pattern recognition to deal with the prediction of the value of one field, based on the attributes of other elements. Associations describe observed relationships between objects based on measured characteristics or quantities signifying some sort of dependence by the objects of interest. This makes use of association rules or sets of frequent items (Lawrynowicz & Tresp, 2014). Clustering aims to group a set of objects based on their similarities and separate dissimilar objects into other clusters. This is a form of unsupervised learning and is also described as cluster analysis (Lawrynowicz & Tresp, 2014).

APPLICATION AREAS OF AI AND ML IN LIBRARIES

The application of AI in libraries and the broader field of information science originated from the rapid technological developments of big data, the Internet of Things (IoT) and virtual realities. Yu et al., (2019) in describing the AI-enabled smart library characterise it as a hybrid of low-cost and people-oriented green technologies integrated and among these are RFID, IoT, the internet, image recognition, speech recognition and PDA. These innovations are characterized by physical space intelligence, information resource intelligence, organization intelligence, service intelligence and management intelligence. Such innovations have sought to provide both library users and library staff with efficient and high quality and attractive information environments. They have been used to support intelligent procurement, automation, collecting and analysing users' personalised information, reference services, book reading, shelf-reading, virtual reality for immersive learning, collection development, information retrieval and technical services, among others (Omame & Alex-Nmecha, 2020; De Silva, 1997; Shanmugam, 2017; Cox, 2022; Chelliah, Sood & Scholfield, 2015). They have also been used to support intelligent warehouse management, supporting self-service management of books and circulation, shelf management using robots, intelligent security management and consulting services. While there has been a wide research on the application of AI and ML in LIS, Das & Islam (2021) in their thematic review of literature developed identified major application areas of AI and ML in LIS as; Collection building and management, Circulation and User Services, Processing in libraries, Reference services, Library administration and Library customization. The application of AI in these areas has resulted in improvements in automated library retrieval systems, improved usage monitoring, quicker checkouts, improved patron services, improved security, improved inventory capacity and smart shelves.

Although AI has made significant contributions to Automated Storage and Retrieval Systems, its adoption in academic libraries is still in its infancy (Wang & Lund, 2022). From the literature cited by

Winkler & Kiszl (2021), virtual and discovery services were the most affected by AI, followed by reference services, cataloguing and collection development. Besides those areas, AI technologies had also been applied in searches, recommendations, personalization, text and data mining and data collection, Information services, Subject librarians, Education, Virtual online services, IT support, and Digitizing.

Robots and Library Management

Wang & Lund (2022) further reported that AI and robots could be useful for intelligent security services and library consulting services citing examples at the University of Birmingham and the security company (G4S) who had developed 'Bob' a robot that monitored cleanliness of desks and closeness of fire doors. In addition to this, AI could also be used to develop recognition technologies to identify users and resources in the library.

The use of AI in recent years has proved to be useful for supporting library services in pandemic periods as the COVID-19 pandemic. Robots in libraries were used to detect symptoms and recommend further testing in countries such as Germany, France and Pakistan among others (Ali, Naeem & Bhatti, 2020). Additionally, some libraries in the developed world have developed robots for performing routine library tasks such as locating and retrieving items (Calvert, 2017). Other common applications of robots in libraries as reported by Calvert (2017) are shelf reading and reporting the results of the exercise to human staff, picking items on orders from humans and based on inbuilt databases, navigating the building and locating items. Among these libraries that have used humanoid robots was the State Library of Queensland which used the robot in developing digital literacy skills of library staff and community (Nguyen, 2020). In Africa, some of the libraries that have adopted humanoid robots are the University of Pretoria and the University of Lagos, which have used the robot for reference services (Echedom & Okuonghae, 2021).

Circulation Services

Advances in AI have seen the emergence of self-service systems in at circulation points in academic libararies. This has been achieved through the use of robots(Iglesias, 2013). In Australian libraries, humanoid robots with capabilities to perceive their environment, recognize faces, read emotions and communicate with people have emerged as useful tools in libraries (Nguyen, 2020). Such technologies are also capable of unndertsnading users' needs through the analaysis of personal data and behaviours. This information is then used to provide relevant and timely services, recommending books, sending reminders of overdue, alerting librarian on books lost by users and recommending possible places where users may purchase books to replace lost items.

Reference Services

Additionally, AI-based reference services have facilitated information seeking by users, assisting them to locate information with minimal effort without having to recall links or pathways (Kaushal & Yadav, 2022). Computerized reference services are argued by Kibirige (1998) to overcome communication barriers that may exist between the library user and the information professional. This has been achieved through the use of chatbot applications which have acted as digital assistants (Nawaz & Saldeen, 2020). Chatbots have been used as virtual agents resulting in improved customer satisfaction, improved services, and customization of user services, particularly among the so-called millennials who consider voice calls

to be intrusive. Additionally, chatbot reference services free library staff much-needed time to support research and contribute productively towards satisfying the information needs of library users. Meincke (2018) with a team of library professionals at Johnson and Wales University developed a chatbot for library services to address challenges related to library working hours and availability, based on Python programming language. This chatbot was able to handle basic library questions related to library working hours, locate books and articles, provide basic library information and even tell jokes.

Collection Development

There is vast potential for the application of AI in collection development. Asemi & Asemi (2018) suggests that these could be in the selection of books, publishers and sellers. Additionally, AI-based intelligent agents have become popular in libraries for their main functions which are, reasoning, planning, learning and collaborating (Herron, 2017). These agents have further been used in assisting users to navigate and interact with online information, finding information and retrieve information. Intelligent agents could be used to search, sort, filter and create user profiles.

AI in Indexing and Abstracting

The area of indexing and abstracting has benefited from the use of AI. CiteseerX utilizes AI techniques in many of its components such as document classification, de-duplication, automatic metadata extraction and author disambiguation among other components (Wu et al., 2015). Metadata research has become paramount as a result of the need to improve modern information storage, preservation, discovery and retrieval. For modern-day librarians, information seekers must not only be able to find, identify, select and obtain information, but they must also be able to explore and improvements in metadata standards and best practices are key in supporting these endeavours (Green, 2021). This has been applied in academic libraries' digital libraries and institutional repositories.

MACHINE LEARNING APPLICATION AREAS

Machine Learning in Instructional Methods

ML learning applications have been applied in the library's function of information literacy instructional methods. In their review, Korkmaz & Correia (2019) reported ML in developing computer marking systems which could provide immediate feedback using NLP. In addition to these, they also cite other intelligent tutoring systems that direct student learning progress and make recommendations on what to follow. Such systems comprise learning progress models and a reasoning engine, enabling the system to decide on the most efficient learning path for the learner using vector space. Text summarization, estimation of student comprehension of lecture materials and teamwork analysis are some of the application areas that have used ML in education and training.

Machine Learning Discovery Services

Through ML, public discovery services that index scholarly literature has been developed to provide easier means of navigating the web. Among these services are Google Scholar, PubMed, and Semantic scholar among several others (Bartsch, 2022).

Kraus-Friedberg (2019) reported that AI and ML algorithms have benefited academic and medical libraries in determining the relevance of collections, collection development and predicting user needs. Based on Pagerank algorithms, most libraries are using ML techniques to develop discovery layers and searches across multiple collections. Davis (2017) cites several examples of ML applications in libraries and some of these projects have been at experimental stages for example, for searching, experimental discovery interfaces, image analysis, and analysis is space usage. These experimental projects have also been used to provide data from large datasets and to provide access to large datasets, and workstations, thereby assisting library users and researchers in getting access to required information.

Machine Learning in Information Retrieval

In information retrieval, the concept of text mining, particularly as a result of the rapid growth of the web and developments in the social media movement requires new algorithmic methods of text mining to derive meaning and concepts, summarize and extract keywords and provide conceptual categorization of large collections. Examples of pilot projects that have been developed to achieve AKE capabilities include, ConceptNet, COVER, Babelnet and DBpedia among others (Sterckx et al., 2017).

Collection Development

ML has also been used for collection development in libraries. For example, through the use of logic regressing and K-Nearest neighbour. Metadata generation and rich text identification through the use of AI and ML offer a wide range of opportunities for internet resource discovery and innovation enabling tremendous transformations for the academic library. This has been made possible through several crawling algorithms on the web and these approaches can expert guided or focused. Crawling algorithms may be in web mining to determine web and internet usage by users in the field of web intelligence. This enables librarians to develop adaptive and personalised services. In addition to this, web intelligence enables libraries to develop recommender systems (Devedžić, 2004). Web intelligence can also enhance instructional methods in educational environments through the Educational Semantic Web (Aroyo & Dicheva, 2004). The semantic web offers new web-based technologies for providing intelligent access and meaningful and semantically richer modelling of information, applications and their users. This has made web-based educational systems popular among researchers, library users, information literacy programmes and reference services.

Recommender Systems

Based on analyzing user reading and borrowing patterns ML algorithms have been used to develop recommender systems for users and to provide personalized user experience to users through filtering, rating, preference or options that might be of interest to users (Das & Islam, 2021). Recommender systems provide a wider range of services offered to library users. For example, through the use of machine learning, AI systems identify the reading patterns of users and use selective dissemination of information

to provide alerts on new arrivals and new articles. Similarly, machine learning applications can detect similar titles and recommend to users new texts or alternative texts. Based on ML, Tsuji et al., (2014) reported that support vector machines (SVM) and association rules have been used to recommend books to readers based on loan records and bibliographic information. These recommender systems, therefore, provide personalized services to users through RSS feeds.

ML algorithms have also been used for reader ratings, bibliographic data and monograph selection (Xiao & Gao, 2020). This results in improvements in recommended systems that predict and rate user preferences. Recommender systems analyze user profiles, content items and connections between them and try to predict future user behaviours and this has been widely used in e-commerce and e-business such as Amazon, Netflix and Expedia. E-commerce systems and e-business systems have relied on business intelligence, which enables libraries to utilize data analytics to gain better insights into both structured and unstructured diverse data from large collections enabling business managers and librarians to make real-time decisions and improve on their decision-making for better competitive intelligence (Hamad, Al-Aamr, Jabbar & Fakhuri, 2021). This also enables them to create innovative services by identifying market and demand trends among users.

Machine Learning for Indexing

For indexing, both supervised and unsupervised machine learning has been applied in Automatic Key Extraction (AKE). This has also been applied to large collections of documents of multiple opinions (Sterckx et al., 2018). The use of ML in key phrase extraction benefits various NLP applications such as text summarization, semantic metadata, indicating the significance of sentences and paragraphs, text categorization and document clustering, term dimensionality reduction and indexing for search engines which may then be effective in query formulation (Kim, Medelyan, Kan & Baldwin, 2012). Kim et al., (2012) acknowledged that previous tasks involved in key phrase extraction were: candidate key identification; feature engineering; developing learning models; and evaluating extracted key phrases. They further acknowledged however those different ML applications from research carried out at times generated different key phrases and these phrases were ranked differently. Similar applications have been carried out in Automatically Recognized Terminology (ATR) extraction. ATR has been used for a wide range of applications such as machine translation, information retrieval or ontology construction (Astrakhantsev, 2018). However, research on ATR has so far failed to develop universally accepted systems, hence the call for researchers to develop new tools.

CHALLENGES FACED LIBRARIES IN USING AI

Although some disciplines have long been adopting and adapting to the AI environment, the field of library and information science has been indifferent and too slow to adopt these technologies (Wheatley & Hervieux 2019). Research on the use of AI and ML in libraries has shown that the application of intelligent agents in libraries has been minimal and those projects that have been implemented have been in experimental stages (Liu, 2011). Several challenges confront libraries in their endeavours to adopt and use these technologies and among them are illiteracy and ignorance about the potential benefits of AI utilisation in libraries, user attitudes and perceptions, user resistance, unsupportive institutional leadership and inadequate ICT infrastructure in institutions, lack of skills to develop and use AI systems

among library staff and uncertainties among library staff about the security of their jobs among several other challenges.

Wheatley & Herviex (2019) have attributed the low adoption of AI in libraries to reluctance among library staff to change their way of operation. They argue that libraries tend to adopt technologies after these technologies have long saturated markets. In Nigeria, Ajani et al., (2022) report that most librarians expressed fear that the use of AI in libraries could take over their jobs. This is because, with the introduction of technologies that potentially substitute human expertise, the challenge among library staff would be fear of being dispensable and ambiguity and uncertainties associated with institutional changes. This is because intelligent machines (robots and chatbots) have become capable of shelving books, retrieving information, answering reference questions and attending to queries. These fears among librarians have led to user resistance to adopting these technologies.

Technophobia towards new technologies may result from several issues. Among these issues is fear of the unknown and lack of skills and the need for retraining among librarians. Saibakumo (2021) found a lack of skills and lack of ICT staff among Nigerian libraries as one of the reasons libraries had given low attention to AI utilisation in libraries. Gasparini & Kautonen (2022), in a review of literature on librarians' roles in an AI environment, recommended that libraries develop new skills that suit the new AI environment and encouraged them to abandon their old paradigms, practices and workflows for example in producing metadata. Shrivastava (2018) also argued that the penetration of these tools in libraries has been low because these tools have just recently become available in libraries.

For many libraries in academic institutions, particularly in the developing world, competition for resources has had a great impact on ICT investments in libraries. Despite libraries playing a major role in teaching and research, institutions often prioritise academic faculty funding while some libraries have continued to rely on donations. These libraries often lack sufficient infrastructure for supporting new digital innovations. Some libraries have even failed to consistently subscribe to journal articles. Such inadequately funded libraries, therefore, have found it difficult to adopt emerging technologies such as AI, choosing to rely on traditional operations, which nowadays have become ineffective in addressing the dynamic information needs of the knowledge and information society which are key drivers of the 4IR. Using UTAUT and structural equation modelling among Nigerian academic libraries, Owolabia et al., (2020) and Dahiru et al.,(2020) reported that although several libraries in Nigeria had embraced automation, a large number among them continued to face challenges due to wrong choices of software, technical difficulties, maintenance challenges, poor revision policy and prohibitive costs.

Lack of knowledge among senior library staff hinders the adoption of smart technologies across various institutions globally. For example, Wheatley & Hervieux (2019) reported that among academic libraries in Canada, the use of AI was never mentioned in libraries' strategic plans. For any innovation, particularly, in the field of information systems to succeed, the institutional strategic plan must integrate these innovations into their competitive strategies. Their omission therefore from the organisational strategic plans renders their adoption a distant possibility, resulting in fewer universities incorporating AI in their activities. While AI has generally been accepted as an innovation in libraries, research has shown that most librarians neither read literature on AI nor participate in AI-related training, making it difficult for them to lobby for AI-related technologies in libraries.

Academic libraries in different geographic regions are generally differentially resourced. This creates a gap in technology acquisition and utilisation among these institutions. While some library associations and unions have encouraged collaboration among libraries, Wheatley &Hervuex (2019) reported that there was little collaboration among Canadian libraries and this created a technological gap among these

libraries. Collaboration among libraries encourages technology diffusion and skills exchange which may be beneficial to ill-equipped libraries.

Zheng (2019) also reported that most librarians are not involved in decision-making related to library robots although they are the most affected by the use of these technologies in libraries. As a result, there is a lack of consensus among librarians on the use of AI in libraries and for most in the developing world, the adoption of AI depends on the working environment characterised by uncertainties in job security while some librarians doubt the reliability and effectiveness of AI. The exclusion of libraries in the decision-making process, therefore, renders them ineffective in recommending training for library staff.

Among some challenges that have limited the adoption of AI in libraries and the library school algorithmic illiteracy among librarians. Algorithms in ML and deep learning according to librarians are too complex, opaque and invisible (Ridley & Pawlick-Potts, 2021). With limited algorithmic literacy, library professionals would not be able to interpret unstructured data and model outcomes for decisions to predict future service and resource demands. It would also be impossible to predict the training needs of library staff and evaluate the strength and weaknesses of ML algorithms

Literature generally suggests that individuals adopt technologies that they perceive to be effective in enhancing their productivity. In their study on the potential role of a librarian in an AI-dominated library environment, Wheatley & Hervieux (2019) reported that in the USA and Canada, a few institutions were participating in the creation of AI hubs and that there was generally a lack of awareness to the AI trends in academic libraries and that while research on AI had been exponentially increasing in other fields, this had not been the case in the discipline of information science.

Challenges related to the adoption of AI in libraries may also be traced back to the Library and Information Science curricula that are offered in library schools. From the literature, there are a few schools that offer modules on AI for library and information science programmes. To that end, therefore, Kranch (1992) in the investigation of the teaching of AI and expert systems in the LIS curriculum in the USA for ALA-affiliated institutions recommended the inclusion of AI courses in LIS programmes, particularly at master and doctoral levels.

Another challenge related to the use of AI in libraries is their dependence on electricity and their vulnerability to malfunction. In addition to this, AI systems are not capable of executing tasks which they were not programmed to do. This makes them ineffective when compared to humans(Omame & Alex-Nmecha, 2020). For many communities particularly in the developing world, for example in Southern Africa, nations have struggled to consistently provide electricity for their communities. This has made it difficult to implement technological innovations that demand high electricity demand.

AI adoption and use in academic libraries have brought with it ethical issues that libraries intending to adopt AI have been compelled to address. Among some ethical issues that arise generally in information science as identified by Cox(2022) are confidentiality and privacy, professional development, integrity, conflict of interest and personal gain, free access and equal access to information, censorship and responsibilities to the profession. In research on ethics in library science, however, Cox (2022) identifies key ethical challenges as related to bias, transparency, privacy, safety and security and human choice. Machine learning algorithm reliability is often determined by the programmer. AI can lead to bias based on algorithm flaws. Nayyer & Rodriguez (2022) argued that the use of ML algorithms in librarianship often includes bias, that is, reliance on irrelevant factors and negatively imbalanced outcomes which may affect the quality of decisions made by the system. Nayyer & Rodriguez (2022) argue that these technologies are not neutral, they embed and magnify prejudices and stereotypes, perpetuating errors and limitations in the training of accumulated data. Often these errors originate from human encoders. Another ethical challenge that confronts the use of AI in librarianship is learning analytics. Learning

analytics according to Jones &Hinchcliffe (2022) requires access to data and information about users either as individuals or as groups and this raises questions about privacy. This process enables data users to utilise computing power, viewing hidden insights which may be beyond the scope of the mandate of the AI systems, raising ethical issues related to the responsible use of data. These techniques are intrusive to patrons although they may contribute to service improvements. Additionally, concerns have been raised about how stared data may be exploited. While AI may anonymise data, it is possible for users to make inferences and identify identities of data subjects and this tends to increase anxiety about the privacy of data stored in AI systems. In addition, the use of ML algorithms often generates decisions that are difficult to explain having emerged from discovered patterns (Cox, 2022).

Advanced technologies such as big data, IoT and geographic information systems present challenges related to the ethical collection and analysis of data. The use of sensors and unmanned aerial vehicles (UAV) in data collection often limits controls that may be applied to data collection resulting in the creation of large data sets comprising irrelevant data elements. This often creates uncertainties among librarianship and library users about what data AI systems hold about them.

IMPACT OF USING AI IN LIBRARIES

While some LIS professionals have regarded AI technology as disruptive, threatening their day-to-day traditional ways of operation, this technology also promises to offer many positive enhancements to a multitude of library services (Massis, 2018). From the literature, Arlitsch & Newell (2017) and Schreur (2020) argue that the use of AI in libraries has the probability of reducing library technicians by 99%, library assistants by 95% and librarians by 65%. The use of AI, therefore, has provided unlimited opportunities for reducing operational costs in a library and allowing the redeployment of library staff to other essential areas of the library. However, Scheuer (2020) acknowledges that despite these changes, AI has provided unprecedented levels of accessibility to library resources while preserving the library staff. This shows that the use of AI in libraries may result in some transformations of the library and the profession at large calling for the integration of skills with disciplines such as data analytics, statistics and computer sciences. This creates employment opportunities and opens new career opportunities in library and information science. This has also forced some library schools to consider radical changes in their curricula to offer and accommodate new training programmes and courses that prepare the young library and information science graduates for the new digital and technologically driven library. Among some skills that would be required in modern libraries according to Igwe & Sulyman (2022) are computational thinking, data literacy, information literacy, social intelligence, trans-literacy and trans-disciplinary thinking and mindset and project management.

While in Hungary, Winkler & Kiszl (2021) reported that a third of the respondents reported the major opportunity of AI in automation. AI and ML applications have broken barriers to their application areas. In the field of librarianship, which itself has evolved and diversified its services, departing from the traditional library environment to offer new services such as language instruction, NLP has the potential to support computer-assisted language learning (CALL) where users are guided through an interactive process where a user responds to some request from the AI-based system by providing a sentence which goes through some series of process that determines grammatical accuracy, with examples being BRIDGE, MILT and ARI among others (Holland & Kaplan, 1995).

CONCLUSIONS

The application of AI and ML has spread across all housekeeping functions of the library together with strategic decision-making levels in the library. However, there has been limited adoption of these technologies with most projects being at the experimental level, particularly in the developing world. The adoption of these technologies has faced several challenges which may be technological, organisational, human and environmental. Despite these challenges, the use of AI and ML has improved library services, operations and management. However, their adoption has also demanded new skills among library professionals as a result of the diverse information needs and the big data environment in which most libraries find themselves operating in.

RECOMMENDATIONS

With several challenges faced by librarians in the adoption of AI and ML resulting in the lower adoption of these technologies, the study made the following recommendations:

a) Pre-service and in-service training for librarians on AI and ML applications in libraries to improve their attitudes and perceptions towards these technologies in libraries.
b) Libraries particularly academic libraries and public libraries should invest in AL technologies to support library functions. This is because libraries have faced an increasing number of users, large collections with complex datasets and diverse sources of information such as the web and the internet.
c) Library schools and training institutions must incorporate AI and ML in their curriculum. This will improve librarians' skills in digital technologies and also has the potential to improve their attitudes towards AI and ML. In addition to this, knowledge of AI and ML will enable library professionals to recommend better innovations for libraries and to develop these innovations in-house.

FUTURE RESEARCH DIRECTION

The study further recommended further studies on the application of ML algorithms in the library. This is because with modern and user-friendly programming languages such as Python, innovations based on ML may easily be developed to support library functions. This is particularly relevant in the areas of web mining and web intelligence because of the libraries'' dependence on web and internet information.

Few researchers have investigated the ethical dimensions of the use of AI in academic libraries. The chapter, therefore, recommends future research on ethical issues of using AI and ML in library science and librarianship.

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